Assessment of Heavy Metal Concentration in Water, Suspended Load and River Bed Sediments of Suvarnavathi River, Chamarajanagara District, Karnataka, India

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INTRODUCTION

Ecological and global public health issues of water contamination are prime concern of the modern society (Reza et al. 2010, Ali et al. 2013 and 2017, Hashem et al. 2017, Gabrielyan et al. 2018; Kacmaz 2020). The problem raised with the accelerated heavy metal concentration sourced by global urbanization cum industrialization since 1940s (Khan et al. 2004, Merian 1984 Banerjee et al. 2016, Pobi et al. 2019, Shankar 2019). The heavy metal contamination is widely noticed in all different domains like hydrosphere and atmosphere (Chakravarty and Patgiri 2009, Chatterjee et al. 2007, Feng et al. 2017, Gao and Chen 2012, Dou et al. 2013, Li et al. 2014, Xu et al. 2014, Darwish 2013) mostly added from the weathering of metallic rocks and volcanic eruptions with some anthropogenic sources like industrial emissions, mining, fertilizers and combustion of fossil fuels (Hatje et al., 1998; Spiegel et.al, 2002; Amman et al., 2002; Nouri et al., 2006; Nouri et al., 2008). The heavy metal can toxicate the food chains causing different health problems (Sharif Fazeli et al., 1991) while chronic exposure will be a real threat to living organisms (Wieczorek-Dąbrowska et.al, 2013).

Naturally occurring heavy metals from the Earth's crust increases toxicity in the environment and due to their low-biodegradability and detrimental nature they effect plants, animals and human being adversely (Nuremberg 1984; MacFarlane and Burchett 2000; Fernandes et al., 2008; Tuzen, 2003, Fernandes et al., 2008). Heavy metals are natural components of the Earth's crust and cannot be degraded nor destroyed. Their natural sources in the environment include weathering of rocks and volcanic eruptions, while principal anthropogenic sources include industrial emissions, mining, smelting, and agricultural activities like application of pesticides and phosphate fertilizers. Heavy metals are kept under environmental pollutant category due to their toxic effects on plants, animals and human being (Nuremberg 1984; MacFarlane and Burchett 2000; Fernandes et al., 2008; Tuzen, 2003). Anthropogenic activities such as industrialization, urbanization, mining, smelting operation and agriculture have locally increased the levels of heavy metals such as Cadmium (Cd), Cobalt (Co), Cromium

(Cr), Lead (Pb), Arsenic (As) and Nickle (Ni) in soil up to dangerous levels ((Table 1.3) (Forstner 1990; Ross 1994; Tessier and Hare 1996; Klavins et al., 2000; Tchounwouet al., 2012). They enter the human body through food, water, and air and are widely distributed in all environmental components. Heavy metals, due to their non-biodegradability and tendency to cause detrimental effects in human beings, are considered as the most hazardous and toxic pollutants (Fernandes et al., 2008) (Figure 1.1).However, the rivers play a major role in assimilation or transporting municipal and industrial wastewater and runoff from agricultural and mining land (Singh et al., 2004).

Suvarnavathi River is a sixth order river and it rises near Gajjalahalli southeastern portion of Chamarajanagara and flows in the depression along the central part of Chamarajanagara taluk with a north-south disposition. It follows northerly direction through Chamarajanagara and Yalandur taluks and joins the river Cauvery at Hampapura in Kollegal taluk. The river has a catchment area of 1787 sq.km with total flow length of 88 kms. Suvarnavathi sub-watershed lies in between 11°40’00’’ to 12°10’00’’ N latitude and 76°48’00’’ and 77°12’00’ E longitude. Suvarnavathi is a seasonal river, flows during monsoon and post-monsoon season. A dam is constructed across this river at Atgulipura adjacent to the Punajanur state forest which serve as border between Karnataka and Tamil Nadu states. Chikkahole is the tributary of Suvarnavathi, rises at Hasanur ghat range to the south of Chamarajanagara, flows in northerly direction and joins Suvarnavathi River at village Hongalayadi. The area classified as partly maidan and general tableland with plain, undulating and lofty mountain ranges covered with thick forests are noticed with N-S trending hill ranges (Western Ghats). The study area mainly comprises of Charnokite and Peninsular Gneissic complex. The southern and eastern parts in the district converge into group of hills with general elevation ranging from 600 to 1,700 mt above MSL. Dense forest noticed in the Southern and Southwestern parts of all 4 taluks. The study area receives rainfall from South-West monsoon from June to September and North-East monsoon from October to December. The average annual rainfall of the district is 791 mm.

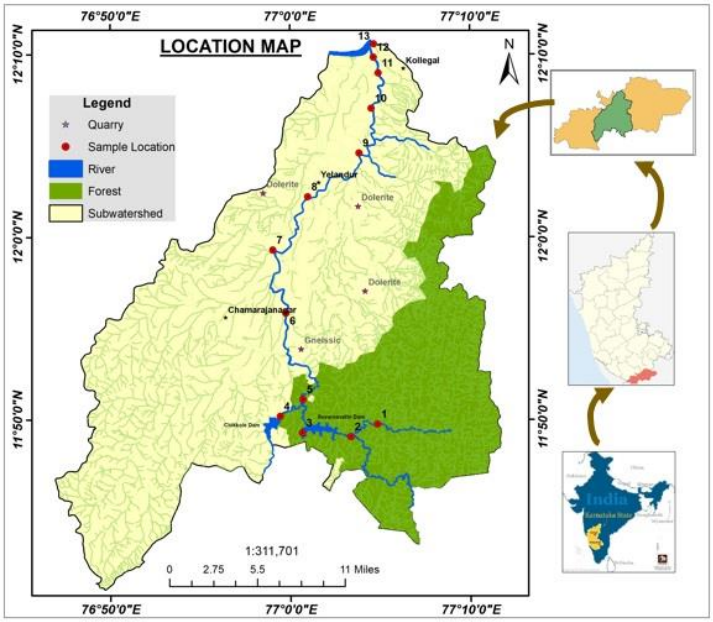


Fig.1 Sample location map of the study area

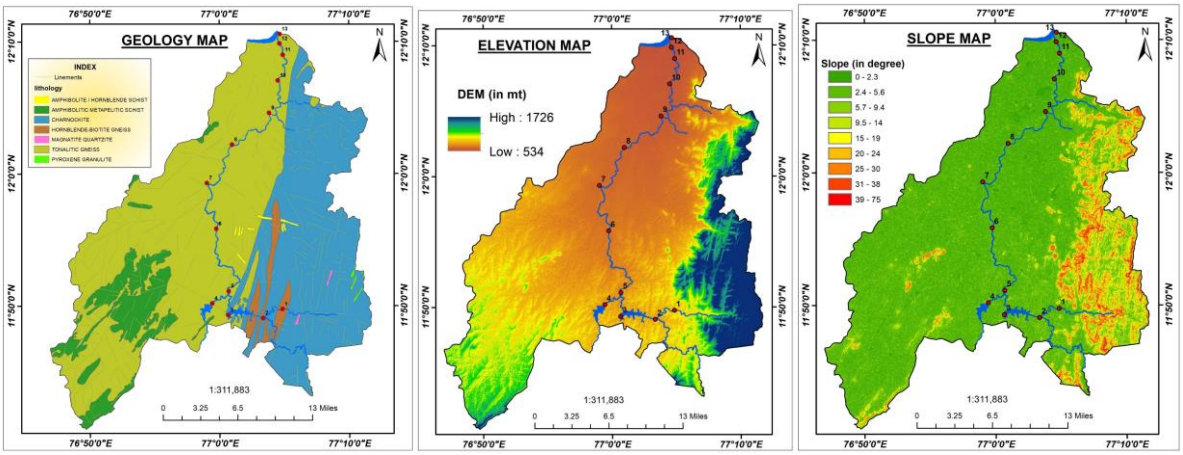


Fig.2 Base maps of lithology, Elevation, Slope, Drainage, Water bodies and Road network.

OBJECTIVES OF THE PRESENT WORK

- To seasonally monitor the concentration of heavy metals in the river water, bed sediments and suspended load from Suvarnavathi River.
- To determine some of the physico chemical characteristics of river water.
- To evaluate whether anthropogenic processes have contribution to the observed metal concentrations and
- To identify the factors controlling their interrelationships of heavy metals in river components.

SCOPE OF THE STUDY

The study area of mainly drained by the tributaries of Cauvery like Suvarnavathi and their tributary systems. Suvarnavathi River flows through the central part of Chamarajanagara taluk, Yalandur taluk and joins the river Cauvery in Kollegal taluk. Suvarnavathi River is the main source of water for irrigation in nearby villages. A dam is constructed across this river at Atgulipura and also it is the source of drinking water for adjacent villages in Chamarajanagar. This study includes seasonal analysis of heavy metals of the river water, Bed sediments and suspended load to understand the overall metal concentration. Furthermore, the study will also include the determination of some physico-chemical parameters. This study is useful for further more towards pollution of the river and water bodies in study area, also groundwater quality and management studies and future development and management of Suvarnavathi River and sub-watershed.

ORGANIZATION OF THE THESIS

The thesis has been organized under six chapters and contents of each chapter are given below:

CHAPTER 1: INTRODUCTION

This chapter deals with the brief introduction about assessment of heavy metal concentration in river water, suspended load and river bed sediments of Suvarnavathi River. This is followed by a general review of literature of the work done on heavy metal assessment and contamination of the river water, suspended load and bed sediments of different parts of the world as well as India. Objectives of the present study and general description of study such as geology, hydrology, agriculture, soil and rainfall are included. An attempt has been made to evaluate the heavy metal distribution pattern in river water, suspended particulate matter and bed load sediments and interrelationship with anthropogenic activity.

CHAPTER 2: MATERIALS AND METHODS

The second chapter gives the details of the sampling locations and materials involved. And also methodology adopted for sampling, sample preparation and analysis of the various matrices. Thirteen samples were collected along the Suvarnavathi River during Pre-monsoon (February 2017-2018), monsoon (June 2017-18) and post-monsoon (November 2017-18) to determine the heavy metal concentration and their variability with seasons. Physico-chemical parameters of water, heavy metal analysis of river water, suspended load and bed sediments have been carried out by adopting different methodologies.

CHAPTER 3: HEAVY METALS IN THE RIVER WATER

This chapter deals with the determination of heavy metal and physico-chemical parameters of river water such as pH, Electrical Conductivity, Total dissolved solids, Total hardness and Major elements (Na, Ca, Mg, K, Cl, NO3, PO4 and SO4) were determined by suitable methods and instruments. Concentrations of heavy metals (Cu, Zn, Pb, Ni and Fe) in Suvarnavathi River water have been analysed by using Atomic Absorption Spectrophotometer available at USIC, Mangalore University and dept. of

Environment Science, University of Mysore. The seasonal variations of heavy metals in river water are discussed in detail in this chapter.

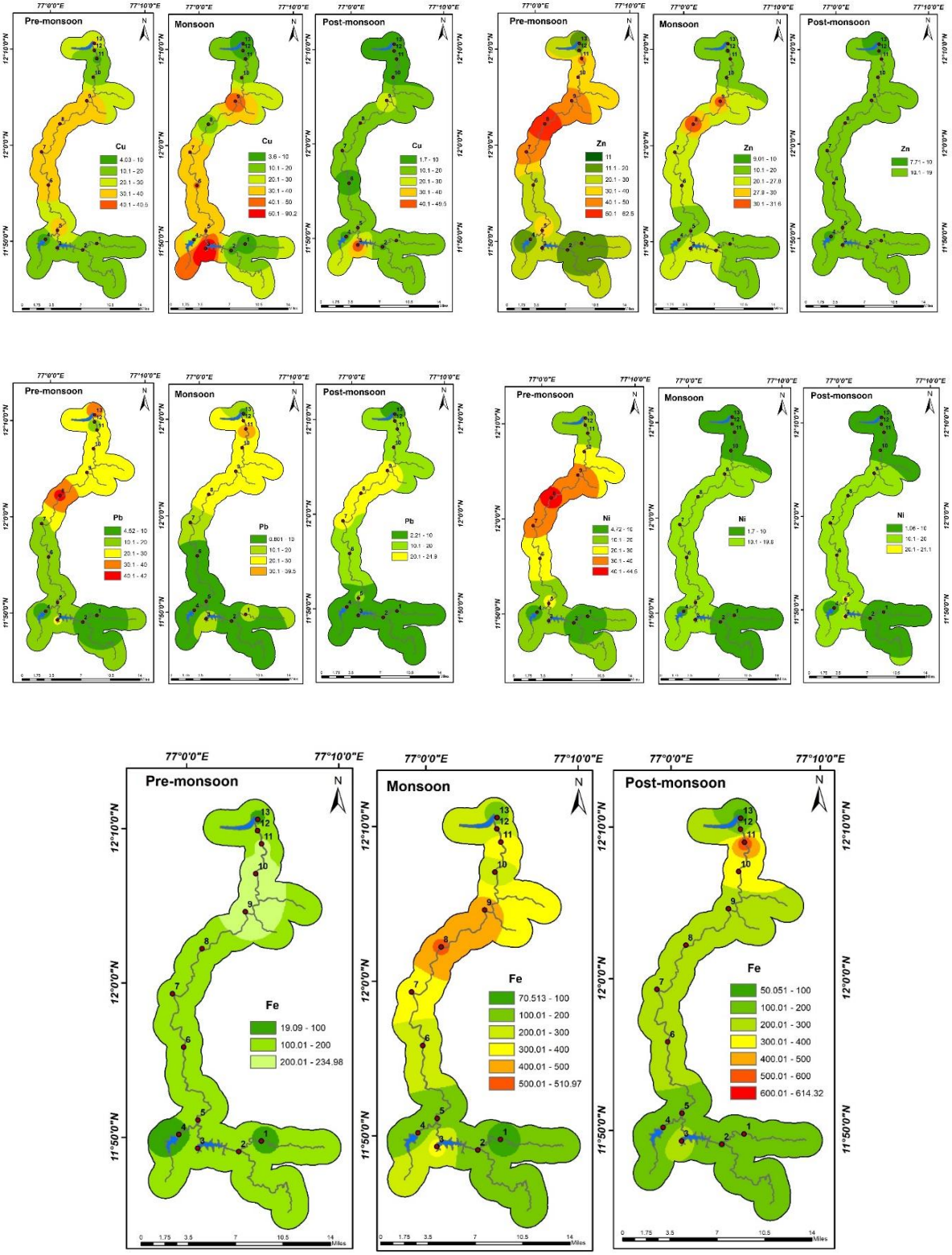


Fig.3 Spatial distribution of heavy metal (Cu, Zn, Pb, Ni and Fe) level in the Suvarnavathi River water during assessment period (2017-2018).

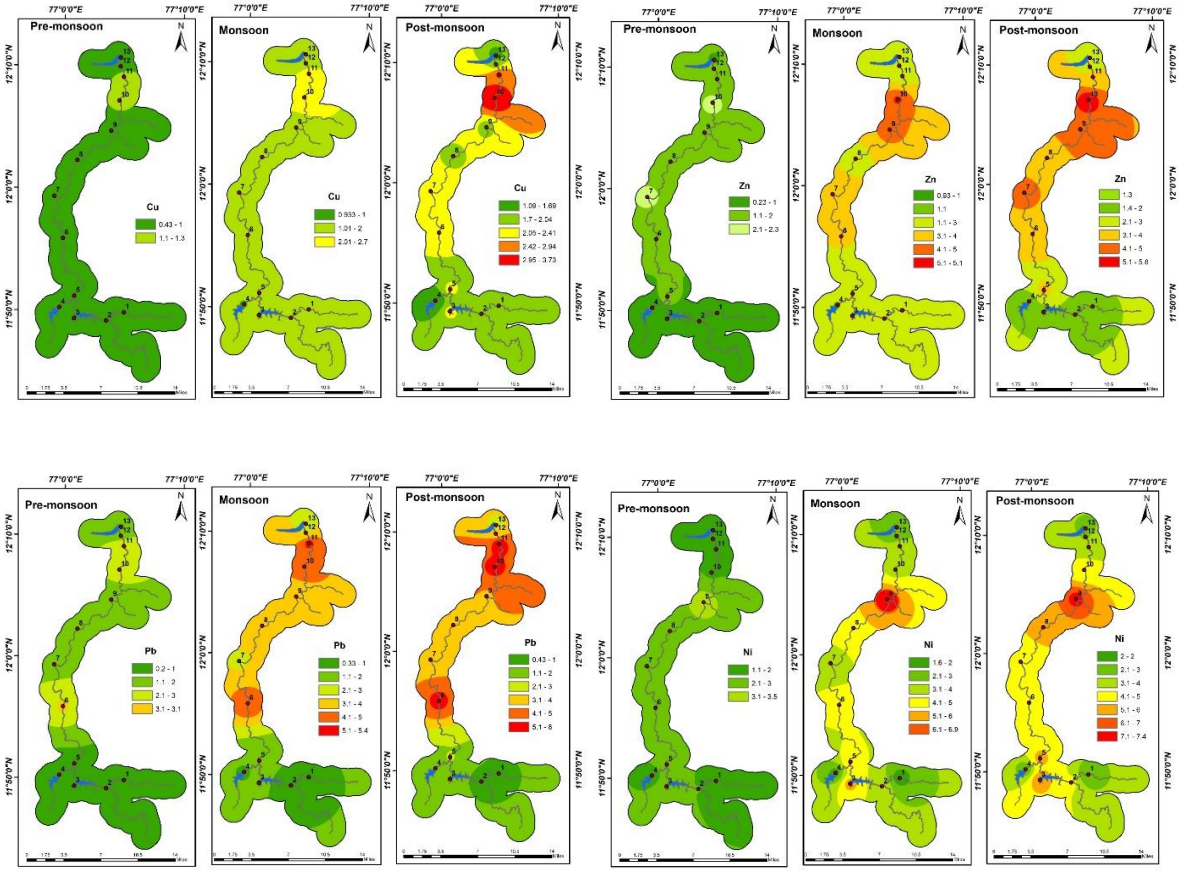
Surface waters are most vulnerable to contamination due to their easy accessibility for disposal of wastewaters. Both the natural processes, such as precipitation inputs, erosion, weathering of crustal materials, as well as anthropogenic influences viz. urban, industrial and agricultural activities, increasing exploitation of water resources, together determine the quality of surface water in a region. Seasonal variations in precipitation, surface run-off, interflow, groundwater flow and pumped in and outflows have a strong effect on river discharge and subsequently on the concentration of contaminants in river water.

In Suvarnavathi River, all heavy metals show higher concentration during dry season (pre-monsoon) and low during rainy seasons. Fe and Cu high during monsoon period due to surface runoff, but other metals are high during non-rainy season due to anthropogenic activity. It is observed that the Suvarnavati river tributaries have a lesser abundance of heavy metals and major ions in upper course and increases towards downstream. Because of lithological variations in the catchment area and human activities and also the mixing of small scale industrial effluents and agricultural runoff. Compare to BIS/WHO standards all are in safe limit other than K and PO_4, cross the limit at border during monsoon as per WHO (1993) standards due to leaching effect and irrigation return flow.

CHAPTER 4: HEAVY METALS IN BED LOAD SEDIMENTS

The bed load sediments are sinks for heavy metals entering rivers from pollutant discharges due to human activities. Numerous studies have demonstrated that the determination of metal concentrations in bed load sediments is more sensitive than the dissolved concentrations as indicators of contamination in hydrologic systems. River sediments is the major repository for metals, in some cases, holding over 99% of the total amount of metal present in the system. As a result of complex

physical, chemical and biological processes a major fraction of trace metals (contributed naturally as well as through various anthropogenic activities) is found to be associated with river's bottom sediments. The process and factors that control the scavenging of trace metals by the sediments and their release to the overlying water column must be understood to assess their impact on the environment.



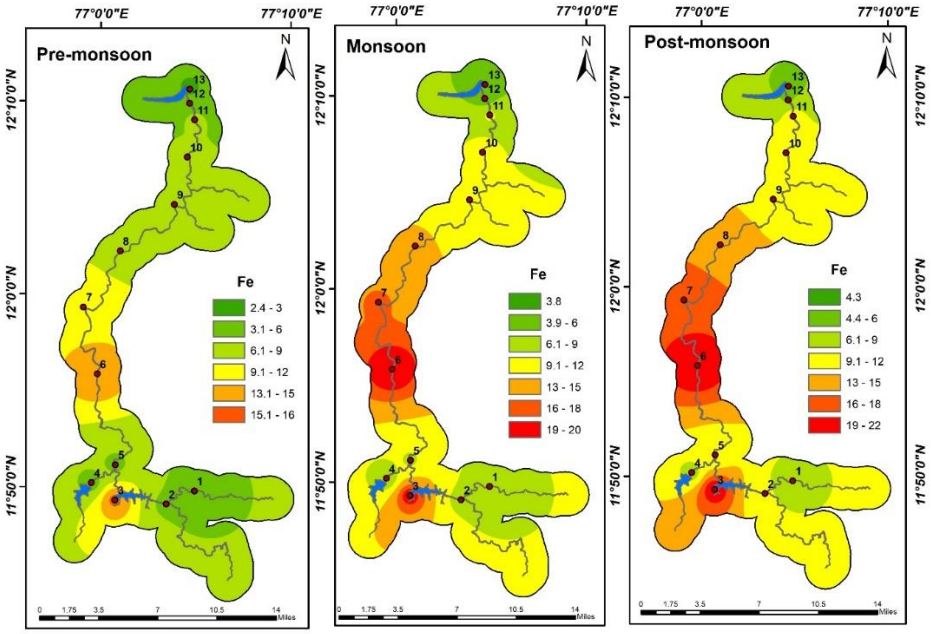


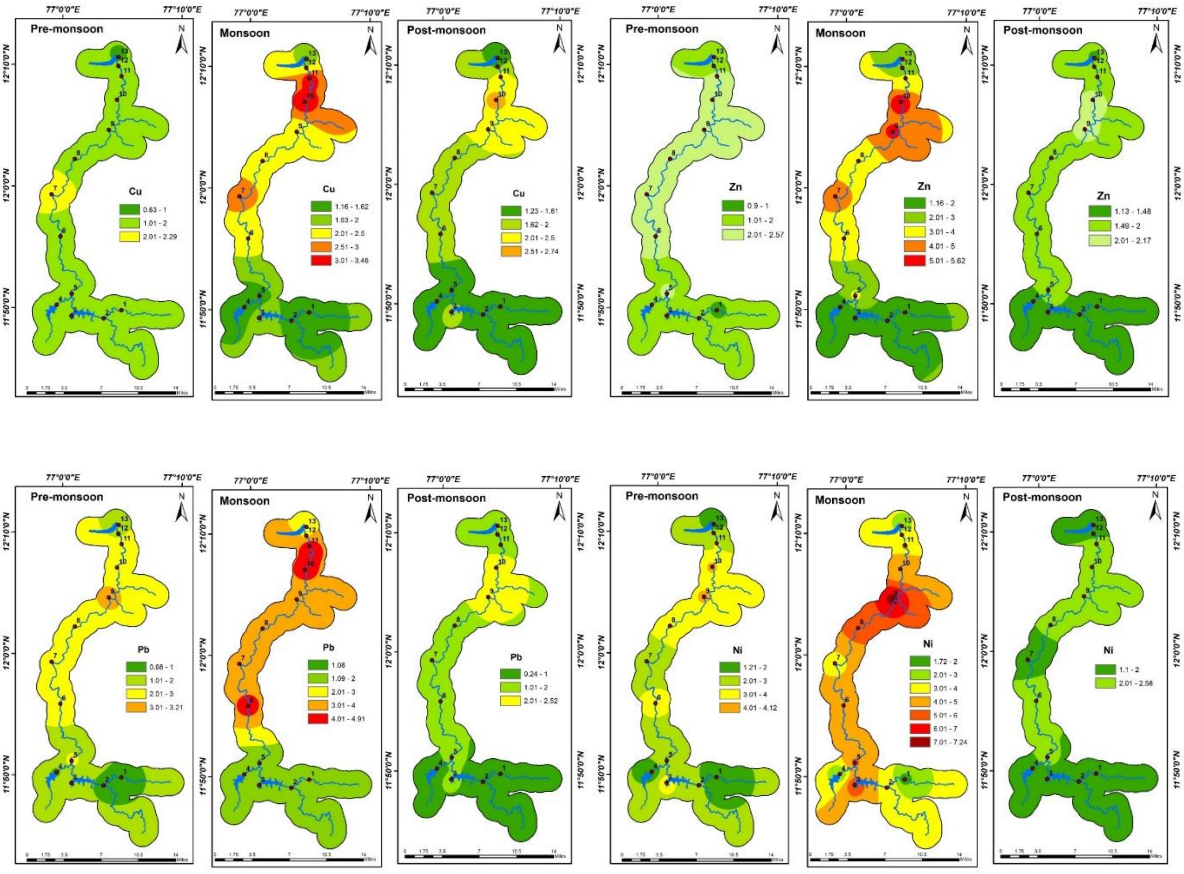
Fig. 4 Spatial distribution of heavy metal level in the Suvarnavathi River bed sediments during assessment period (2017-2018).

During pre-monsoon most of the elements in river bed sediments show lower concentration, but during monsoon and post-monsoon season is enriched with Fe and Na concentration and Cu, Zn, Ni, Pb are enriched to a certain extent. The heavy metals concentration show higher values at confluence points (S5, S8, S9 and S10) mean while major elements values are decrease after confluence points may be due to dilution factor. The river Suvarnavathi recorded very low concentration of heavy metals; Cu, Zn, Pb, Ni and Fe in bed sediments when compare to main river Cauvery (Susheela et al., 2014), average shale and Indian average. The depletion of elements may be attributed to the relatively coarse size of the bottom sediment and to re-suspension of fine particles from the river-bed. The Pb and Zn concentration in bed sediments found almost same range, these indicate that Pb and Zn are the most bioavailable metals in the sediment with significant positive linear relationship (Nur Aliaa Shafie et al., 2014). All metal and major concentration in bed load are well within the guidelines by US.EPA, 2014.

CHAPTER 5: HEAVY METALS IN SUSPENDED PARTICULATE MATTER

Heavy metal contamination in suspended sediments is of particular concern due to its potential risks to human health and aquatic organisms. Metal contamination is traceable to a variety of sources, domestic sewage and waste-water from industrial and agricultural operations including sugarcane farming (which involves the high use of vinasse, pesticides and mineral fertilizers). Depending on the concentrations and residence times of different heavy metals, they have the potential to be toxic to fauna and humans, can cause neurological disorder, mutagenesis, cancer and other type of diseases. Therefore the analysis of heavy metals in the suspended load sediments permits us to detect heavy metal concentration which escapes by water analysis.

SPM during assessment period is enriched with Fe, Cu, Zn, Ni, Pb, Na, Ca, K and Mg to a certain extent. The heavy metal concentrations found in the SPM show least concentration during dry seasons and highest values recorded during the rainy seasons due to surface runoff. Such differences reflect the geological erosion of soil/ rock and load carried by river and anthropogenic inputs into catchment area during



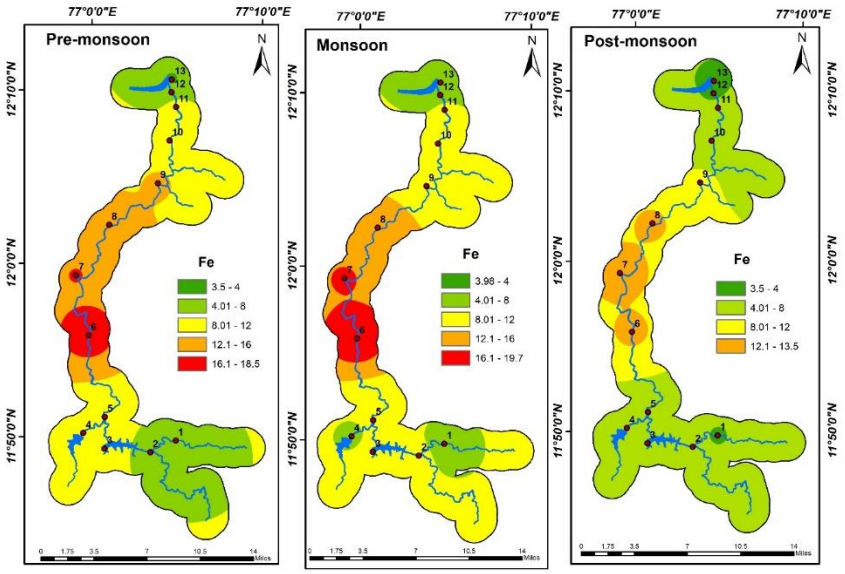


Fig. 5 Spatial distribution heavy metals level in the Suvarnavathi River suspended load during assessment period (2017-2018).

rainy season. The highest values of metals found at stations of confluences, stations near to NH 209 and at river mouth. The major source of both Cu and Zn, found in the suspended sediments, is most likely the sugarcane industry, with its large-scale use of agrochemicals and fertilizers. Another factor that could contribute to the increased concentrations of all the heavy metals in the downstream cross section is the extraction of sand from the bed layers - re-suspension of heavy metals (Hatje et al. 1998; Zhou et al. 2003; and Liu et al. 2005). Most of the elements in Suvarnavathi River bed sediments show lower concentration as compared to SPM during rainy season. This is because the river water suspended load comprises of silt and clay, while bottom sediments comprise mainly gravel. All heavy metals are well within the prescribed limit and recorded low value compare with average world river suspended particulate matter.

CHAPTER 6: SUMMARY AND CONCLUSIONS

In this chapter major conclusions drawn from the work carried out would be highlighted and scope for the future work would also be discussed. The heavy metal contents in river water are more during pre-monsoon due to less water flow and rich in

SPM during monsoon due to surface runoff and leaching effect and high in bed sediments during monsoon and post-monsoon due to re-settling of suspended load from water to bottom of the river. Although the signature of heavy metal concentration noticed higher in lower course of the river because of the agricultural activity, quarrying, silk and sugarcane units and sewage sludge. The study reflecting the role of monsoon rain in diluting the concentration of elements in the river basin. The dissolved elements, quite higher at the vicinity of agricultural land, small scale industries and quarries. Heavy metals concentration are high in SPM compared to water and RBS.

Multivariate statistical methods like PCA, CA and correlation matrix of various season data suggests that the major controlling factor regulating the composition of the suspended and bottom sediment are by weathering, derived from lithogenic source and there appears to be not much of anthropogenic into the river water system. However, they are diluted from the influx of fresh weathered and eroded material from the catchment. This has been prominently seen during the monsoon and to some extent post-monsoon, but not pre-monsoon. As per the relevant standards for Water, RBS and SPM, the heavy metal concentrations are well within the limits indicates the anthropogenic input has not affected the water chemistry to hazardous level and not affected by heavy metals contamination.Relevant suggestions have been made for future development and management of Suvarnavathi River and sub-watershed.

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2. R. Nirmala and C. Krishnaiah (2019). Comparative study of heavy metal concentration in river water and groundwater of Suvarnavathi River, Chamarajanagar district, Karnataka, India.Climate change in water resources, edited by Siddan Anbazhagan et.al, pp: 97-105, 2019, ISBN 978-93-87997-82-0

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LIST OF PAPER PRESENTED

1. Comparative study of heavy metal concentration in river water and groundwater of Suvarnavathi River, Chamarajanagar district, Karnataka, India in 'International conference on Impact of climate change on water resources' (ICWR2018)' held at Periyar University, Salem on July 12 -13, 2018.
2. Spatial distribution of Total Hardness and Total Dissolved Solids in ground water of Suvarnavathi Subwatershed, Chamarajanagar district, Karnataka, India, using GIS techniques in 'International conference on Impact of climate change on water resources' (ICWR2018)' held at Periyar University, Salem on July 12 -13, 2018.
3. Hydro-chemical analysis for the assessment of groundwater quality along Suvarnavathi River, Chamarajanagar district, Karnataka, India in 'National level conference on recent advances in Material science' held at Field marshal K. M.Cariappa College, Madikeri on 5th February 2019.

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